RELATION OF POTATO SIZE TO AFTER-COOKING BLACKENING TENDENCY[1]

JAMES SICILIANO, E. G. HEISLER AND W. L. PORTER[2]

ABSTRACT

An observation made in the laboratory led to a two-year study showing a relationship between after-cooking discoloration and potato size. This relationship, the larger the potato the greater the blackening tendency, was consistent for all potatoes examined in this sudy whether they blackened severely or slightly. These findings may help future researchers correct the conditions that cause blackening.

RESUMEN

Una observación hecha en el laboratorio condujo a un estudio de dos años que indicó una correlación entre la decoloración después de cocinar las papas y su tamaño. Esta correlación consiste en el hecho de que cuanto más grande es la papa, tanto más grande es la tendencia a decouoración y esta correlación se mantiene para todas las papas ya sea que ennegrezcan mucho o ligeramente. Estos descubrimientos pueden ayudar a los investigadores futuros a corregir las condiciones que causan ennegrecimiento.

The after-cooking discoloration problem in potatoes and its importance has been reported (1-16). Briefly stated, this is a black discoloration that occurs only after cooking and is not observed in the raw tissue. It appears during the cooling process and is observed only at the stem end of the potato. For this reason it is also known as stem-end blackening. It is now generally accepted that the discoloration is due to the formation of a dark colored complex of iron and chlorogenic acid, but it is also recognized that the presence or absence of other constituents plays a major role in the blackening mechanism.

The previous publications from this laboratory reported the results of compositional studies of a large number of potato samples exhibiting varying degrees of discoloration, from slight to severe. The chlorogenic acid, potassium, iron, and organic acid contents of stem- and bud-end tissue of these samples and the interrelationships of these constituents were reported and correlations with blackening were established.

Toward the end of this compositional study, while examining a batch of potatoes with severe blackening obtained from a farm in north central Pennsylvania, we observed a relationship not previously reported: within this sample, the blackening was related directly to potato size. This relationship is illustrated in Fig. 1, showing stem-end plugs taken from small, medium, and large potatoes. It is apparent that the plugs from large potatoes were more discolored than the medium, and the medium more so than the small potatoes. After this original observation, a more com-

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[2]Eastern Regional Research Laboratory, Philadelphia, Pennsylvania. One of the laboratories of the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

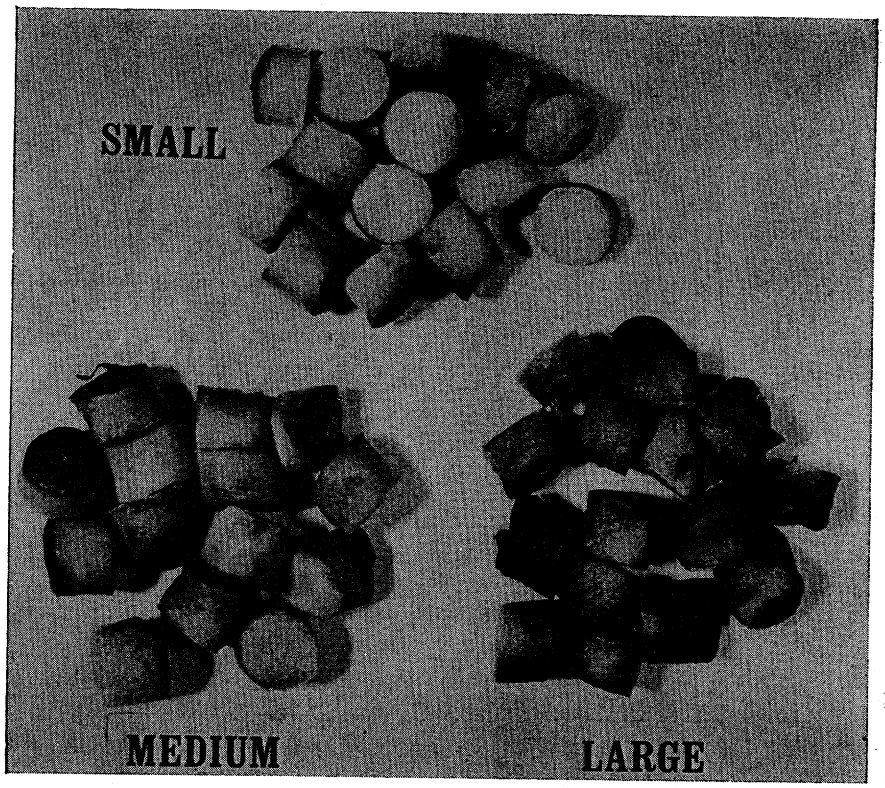

FIG. 1.—Differences in degree of after-cooking blackening; plugs taken from the stem-end of small, medium, and large potatoes.

prehensive study was initiated to determine the size-blackening relationship and to obtain more quantitative results.

MATERIALS AND METHODS

Materials. The study covered two crop-years and several varieties grown in different locations; Katahdin and Kennebec grown in Pennsylvania, Maine, and New York (Long Island), and the two red-skinned varieties, Norland and Red Pontiac, grown in Pennsylvania and Minnesota, respectively.

Potato sampling. Typically, the lot of potatoes under study was sorted into weight groups, each weight group covering a range of 50 g. For example, 50-100 g, 150-200 g, etc., the last group comprising potatoes in excess of 650 g.

Determination of discoloration (after cooking). Longitudinal plugs (approximately ½ inch long) were taken from the stem- and bud-end sections of 13 thoroughly washed and scrubbed potatoes, using a No. 15 cork borer. The center section of each plug was removed with a No. 3 cork borer and discarded. The above work was done in a cold room (50 F)

after which the plugs were immediately steamed in a pre-heated cooker for 35 min at atmospheric pressure. In this way enzymatic activity was kept at a minimum. The cooked tissue was allowed to cool for 30 min. During this time the skin was carefully peeled from the surface and the 13 plugs were weighed and adjusted in length so that their weight equalled 65.00 g. All trimming was done from the inner end of the plug. After the 30-minute cooling period, the 65.00 g of cooked potato tissue (stem- and bud-end) was mashed for 2 minutes in a Waring[3] blender with 13 ml of water. A small portion of the mash was placed in a glass cup (20 mm diameter by 9 mm deep) and covered with glass. The reflectance obtained from this smooth surface (under glass) of cooked mashed potato was taken as a measure of discoloration. The reflectance attachment to the Beckman Model B spectrophotometer was used with $MgCO_3$ (100% reflectance) as standard. The reflectance of tissue from both the stem- and bud-end of the potato was measured. Lower reflectance indicates greater blackening. While the reflectance of the stem-end tissue alone is a measure of blackening, a better measure (and the one used in our previous studies) is the difference in reflection between the stem- and bud-end divided by the reflectance of the stem-end $((R_b—R_s)/R_s)$. The more blackening in the potato the greater is the difference between R_b and R_s and the lower is the value of R_s. Thus, these factors reinforce each other to amplify the value for "degree of discoloration," making the system more sensitive in differentiating samples. Also, when using this value as a measure of discoloration the bud-end of the potato acts as a control and thus any variation in the natural color of the potato flesh between samples tends to be cancelled out.

Results and Discussion

Nine potato samples were studied to determine the relationship of after-cooking discoloration to potato size. For each of the potato samples the reflectance of stem- and bud-end tissue from tubers of varying size was determined. The results obtained are presented in Figs. 2 and 3. In Fig. 2 reflectance values for stem- and bud-end tissue are plotted against potato size for the various samples. In Fig. 3 the values for the ratio $(R_b—R_s)/R_s$ are plotted against potato size. The data shows a general increase of blackening of stem-end tissue (% reflectance decreases) as potato size increases, whereas the bud-end tissue tends to become slightly whiter with increasing potato size. While this general trend is manifested in all the potato samples studied, it is apparent that the degree of increased blackening of stem-end tissue with size varies considerably among the samples. It should be pointed out that the samples studied represent a wide range of blackening tendency. If the results for the 325 g-size tubers are examined, the degree of discoloration $((R_b—R_s)/R_s)$ varied from .400 for the Norland from Pennsylvania to .050 for the Russet Burbank from Idaho (see Table 1). The Norland sample blackened severely and the Russet Burbank sample only slightly. An analysis of the data shows that the potatoes with the greatest tendency to blacken also exhibited the greatest increase of discoloration as the potato size increased (see value for increase of blackening index with 100 g increase in potato size in Table 1).

[3]Mention of company or trade names does not imply endorsement by the Department over others not named.

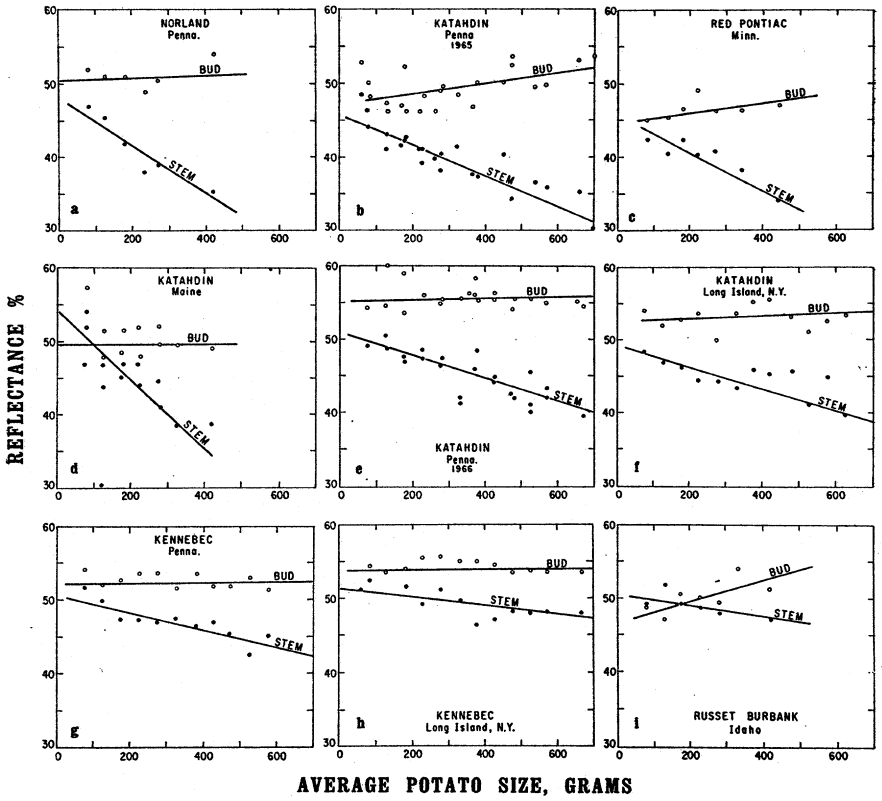

FIG. 2.—Variation of blackening of stem- and bud-end potato tissue with potato size.

Among the samples studied were two of the Katahdin variety: one each from Pennsylvania and Long Island; and two Kennebecs: one each from the same two locations. These samples were selected for this study to enable us to compare directly two varieties grown in the same location. They were picked from the farmer's bulk storage so that a suitably wide range of sizes could be obtained. The results of this comparison are presented in Fig. 4. Both the Katahdin and the Kennebec varieties blackened more when grown in Pennsylvania than when grown on Long Island. It also is apparent that the Katahdin variety tended to blacken more than the Kennebec variety.

In connection with the relationship of tuber size to stem-end blackening, it should be pointed out that when the potato as a whole is considered, i.e., when the reflectance of the tissue from the whole tuber was measured and compared to the stem end, there was only a very slight decrease in the reflectance measurement from the very small to the very large potatoes. Also, the cooked mashed tissue of a large potato that exhibited severe stem-end blackening appeared white. This is illustrated in Table 2. The stem end of the large potato showed severe blackening

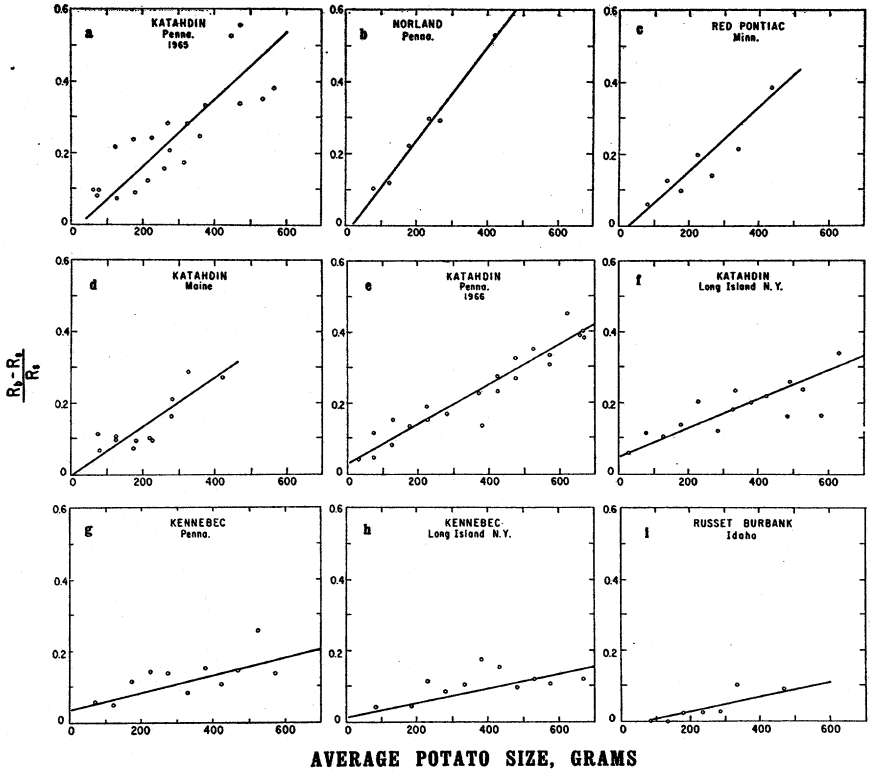

FIG. 3.—Variation of "Degree of Discoloration" with potato size.

TABLE 1.—*Relationship of degree of blackening to increase of blackening with potato size.*

Variety	Crop year	Location grown	Discoloration index ($(R_b—R_s)/R_s$ of 325 g size)	Measure of increase of discoloration index with 100 g increase in potato size
Norland	1966	Pa.	.490	.130
Katahdin	1965	Pa.	.275	.090
Red Pontiac	1965	Minn.	.265	.090
Katahdin	1966	Maine	.220	.070
Katahdin	1966	Pa.	.210	.055
Katahdin	1966	N. Y. (L. I.)	.180	.040
Kennebec	1966	Pa.	.110	.023
Kennebec	1966	N. Y. (L. I.)	.080	.021
Russet Burbank	1966	Idaho	.050	.020

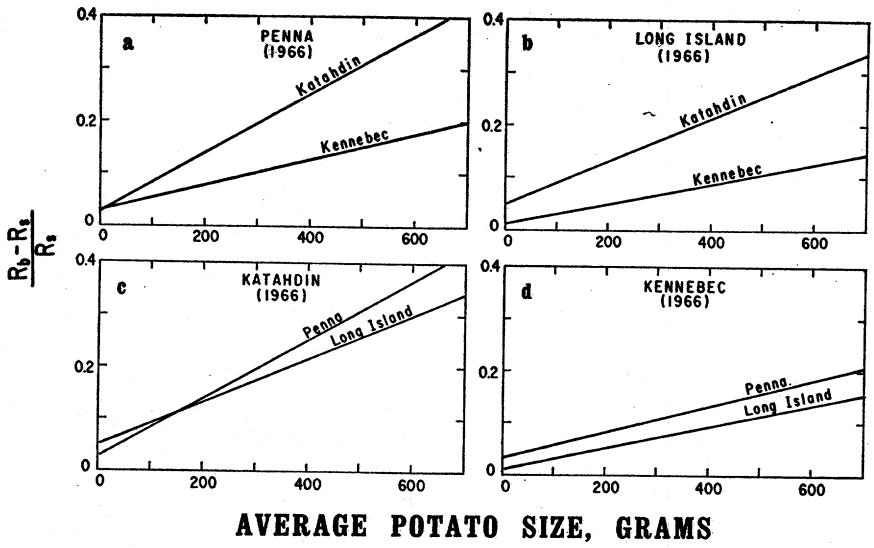

FIG. 4.—Direct comparison of Katahdin and Kennebec potatoes grown in Pennsylvania and New York (Long Island).

(reflectance of 34.8%), with a gradual decrease in the incidence of blackening as the size decreased. The tissue from whole tubers also showed a decrease of reflectance with increase of size; however, the decrease was slight (from 59.5 to 53.9%) and the value of 53.9% for the large size was so high that the whole tissue was considered non-blackening. This situation is explained by the fact that even though there is considerably more black tissue around the stem end of a large potato, there is also considerably more white tissue present to dilute the black tissue when the whole potato is cooked and mashed.

TABLE 2.—*Relationship of tuber size to blackening.*

Potato size range	Reflectance of tissue		
	Stem	Bud	Whole
g	%	%	%
100 - 150	48.5	47.9	59.5
300 - 350	38.9	48.0	54.4
550 - 600	34.8	49.8	53.9

The tuber size stem-end blackening relationship established in this study is interesting from a fundamental standpoint in that it could conceivably provide plant physiologists or agronomists a clue to the basic conditions that cause blackening. From the practical standpoint it might also be of value. If a processor of frozen French fries or dice for soup, for example, had a particularly bad batch of potatoes, he could perhaps trim about

an inch or so from the stem end of the larger potatoes and improve his position considerably, or he could refrain from purchasing large potatoes.

Acknowledgments

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